

# THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 8

OCTOBER, 1923

No. 10

## THE COLORING AND THERMOPHOSPHORESCENCE PRODUCED IN TRANSPARENT MINERALS AND GEMS BY RADIUM RADIATION<sup>1</sup>

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In an earlier paper<sup>2</sup> one of us reported some observations on the coloring, decolorization and thermophosphorescent effects resulting from the radiation of glass by radium rays. Similar experiments, extended to transparent minerals and gems, are described in the present paper.

This subject has already been studied by various investigators.<sup>3</sup> The results recorded here are in the main confirmatory of previous observations, though complete agreement is not to be expected owing to the variations encountered from specimen to specimen of the same material. It therefore seems desirable to report all the results, although many of them duplicate those of previous investigations, in order to be able to consider them together with the other effects described, many of which are new. An additional reason for the joint consideration of decolorization and thermophosphorescence is found in the possible theoretical connection between the two which will be more fully discussed later in the paper.

<sup>1</sup> This article is a reprint in condensed form of a paper by the authors which appeared in the September number of the Journal of the Franklin Institute, (Vol. 196, pp. 375-90). Published by permission of the Editor of the Journal and the Director of the U. S. Bureau of Mines.

<sup>2</sup> S. C. Lind, *Jour. Phys. Chem.*, **24**, 437-43, (1920).

<sup>3</sup> A. Miethe, *Ann. d. Phys.*, **19**, 633, (1906). C. Doelter, "Das Radium und die Farben," Steinkopf, Dresden, 1910, also "Die Farben der Mineralien, Insbesondere der Edelsteine," Vieweg und Sohn, Braunschweig, 1915. E. Newberry and H. Lupton, *Memoirs and Proc. Manchester Lit. and Phil. Soc.*, **62**, No. 10, (1918). St. Meyer and K. Przibram, *Sitzb. Akad. Wiss. Wien*, **123**, IIa, 653-63, (1914). K. Przibram, *ibid.*, **130**, IIa, 265-70, (1921). St. Meyer and E. v. Schweidler, "Radioaktivität," Teubner, Leipzig-Berlin (1916), pp. 191-7; Lit. refs., p. 198. A. Dauvillier, *Comp. rend.*, 171, pp. 627-9, (1920).

The diamond is so unique in its behavior under radium radiation that it will be separately considered in a subsequent communication. In all cases, except the diamond, coloring is produced by the penetrating (beta and gamma) radiation received through a glass wall of ordinary thickness ( $\frac{1}{2}$  to 1 mm.). The diamond, however, did not change color under penetrating radiation, even though prolonged and intense, but responded in every case to direct alpha radiation, either from emanation or by direct exposure to radium salts.

Fluorescent effects are caused in some minerals (kunzite, "active" calcite, willemite, etc.) both by alpha and by penetrating radiation, but in most minerals alpha radiation is the only one producing phosphorescence, while many other minerals do not fluoresce even under its stimulus.

In the following, where radiation is reported in terms of *mgs. of Ra*, we refer to the penetrating radiation from high-grade salt (chloride or bromide), 70 to 100 per cent. pure, placed immediately in contact with the mineral and separated only by the glass wall of the container. Where *emanation* is specified, the mineral has been sealed in a glass tube containing radium emanation furnishing alpha, beta and gamma rays. As in the case of glass, the same color is produced in a given specimen (except diamond), either by emanation or by penetrating rays, more rapidly by the former.

Thermophosphorescence was observed visually by placing freshly radiated specimens in an electrically heated muffle, inspecting in the dark with well-rested eye the light emitted upon gradually raising the temperature. In the case of direct radiation by means of emanation the observations were not made until at least four hours had elapsed after removal of the specimens from the emanation in order to allow the active deposit to decay, thus avoiding any direct fluorescent effects.

The observations for individual minerals were as follows:

*Rock salt* is readily colored to an amber yellow by 250 mgs. Ra in one to two days. It is easily restored to colorless by heating to 300° C. without thermophosphorescence, or by exposure to direct sunlight for one to two hours. Decolorization by diffused light is much slower. The cycle can be indefinitely repeated from color to colorless, either by heat or light, and back to color by radiation.



Through the kindness of Drs. A. W. Hull and W. P. Davey of the General Electric Company, X-ray diffraction spectrographs by the powder method<sup>4</sup> were made both of the colorless and of radium-colored crystals. The two lattice patterns are identical, showing that no change is produced in the colored specimen which can be detected by the X-ray spectrographic method.

*Fluorspar*.—Different varieties, purple, green, rose, and colorless, are readily colored in one to three days by 250 mgs. Ra to various shades of blue and greenish-blue, which color is easily removed by sunlight or by heat. Thermophosphorescence is striking (next in intensity to kunzite) and like kunzite begins at a low temperature. At 70° C. the light is blue, changing to greenish-blue at 125° and remaining unchanged at 150°. At about 180° the crystals decrepitate and the color produced by radium is discharged. A specimen of rose-colored fluorspar could be colored bluish-green repeatedly under radiation and the rose color repeatedly restored either by heating or by light. On the contrary, the purple variety became white at the decrepitating temperature and could not again be colored by further radiation. These observations appear to support the organic coloring theory for the purple varieties, but not for the rose colored.

*Kunzite*.—Different specimens of California kunzite behave with remarkable uniformity both as regards coloring and thermophosphorescence. Under radiation from 50 to 100 mgs. Ra, the original lilac color vanishes and the crystal after twenty-four hours' radiation is almost white, which may be due to color compensation by the green color being produced. In two days the green color is well developed and reaches a maximum about the third day, approaching an emerald green, though somewhat lighter. The color is readily restored to lilac, either by light or by heat, and by ultra-violet light in remarkably short time. The cycle can be repeated indefinitely, apparently without fatigue. Fluorescence under penetrating or alpha radiation is of a characteristic orange-yellow or salmon-yellow, and less brilliant phosphorescence has been observed for more than a month after cessation of radiation. In the long duration of phosphorescence it resembles calcite as well as in the color of the phosphorescent

<sup>4</sup> A. W. Hull, *Phys. Rev.*, **10**, 661 (1917); **17**, 571 (1921); *Proc. Am. Inst. Elec. Engs.*, **38**, 1171 (1919); *J. Am. Chem. Soc.*, **41**, 1168 (1919).

light. In thermophosphorescence kunzite exceeds all of the other minerals hitherto examined. Well below  $100^{\circ}$  C. the intensity of light becomes much enhanced, at  $125^{\circ}$  it becomes a bright yellow, and at  $200^{\circ}$  a watch dial is well illuminated by the light from a small crystal. If raised rapidly to  $250^{\circ}$ , the light is very brilliant, but becomes exhausted rapidly at this temperature, and drops to a much lower intensity with a reddish hue. Apparently simultaneously with exhaustion of most of the light, the original lilac color is restored. In fluorescence kunzite responds immediately to either penetrating or alpha rays from quite small quantities of radium and no marked change in fluorescence is observed as the coloring progresses.

From the standpoint of coloring, fluorescence and phosphorescence, kunzite is the most interesting of all minerals, and together with fluorspar and calcite forms a distinct class.

*Calcite.*—Different varieties of calcite showed the greatest differences in the properties of coloring, fluorescence, and of thermophosphorescence, which vary from complete absence to presence in marked degree. Through the kindness of Prof. William P. Headden of the Colorado Agriculture College, we have had an opportunity of observing some of the effects in special specimens of calcite which he had collected. Some of the varieties were colored yellow by 200 mgs. of Ra in the course of one to two months or by 150 millicuries of emanation in one to two weeks, when contained in rather large tubes. The fluorescence of certain samples is marked under the influence either of alpha or penetrating radiation. The color of fluorescence is a reddish orange and phosphorescence is very persistent at ordinary temperature. The varying behavior of calcite is in marked contrast to the uniformity of kunzite as they came under our observation. The varieties of calcite which are active are quite comparable, however, with kunzite both in fluorescence and phosphorescence produced by radium radiation.

*Sapphire.*—Experiments have been carried out with 25 or 30 specimens of different colors and from various localities, including some synthetic ones. All specimens were uniform in exhibiting no fluorescence, either to penetrating or to alpha radiation. Thermophosphorescence was not observed in natural crystals, but was exhibited faintly by both white and pink synthetic crystals. The thermophosphorescence was characterized by the relatively high temperature at which it appeared (above



150° C.) and at which it persisted (350° for a pink synthetic crystal). At 350° it was more brilliant than kunzite which had passed its maximum at a lower temperature and had dropped to a much fainter intensity. The thermophosphorescence of synthetic pink sapphire was red or orange-red, of synthetic white was yellow, which became paler with increasing temperature. Not a sufficiently large number of natural crystals was examined for thermophosphorescence to be sure that its absence is characteristic.

Change of color under radiation is general, but not universal. Colorless crystals either natural or synthetic are usually changed to golden or canary yellow in two to three days by the radiation from 200 mgs. Ra. Pink crystals either natural or synthetic were easily changed to a burnt orange color, probably corresponding to the addition of yellow to the original pink. Blue crystals change to a grayish or brownish green, without beauty or brilliancy, but the original color can be restored either by light or heat. Light yellow is usually deepened to a canary yellow, but may take green shades instead, which latter may also result in some cases from colorless specimens. In no case observed was the color produced light-permanent, resembling in this respect rock salt, kunzite, and fluorspar.

*Ruby.*—The color changes in ruby are not marked. Light colored natural ruby was not changed by radiation. Synthetic ruby was slightly darkened. Neither natural nor synthetic ruby showed any fluorescence under penetrating radiation, but showed a faint deep red fluorescence in emanation. Synthetic ruby showed a faint dark red thermophosphorescence at 150° C.

*Emerald.*—Neither natural nor synthetic emerald showed fluorescence under penetrating or alpha radiation; nor was change of color produced in any case. Synthetic emerald which had been exposed to 150 m.c. of emanation for ten days showed a faint green thermophosphorescence at 200° C.

*Topaz.*—Several different specimens of colorless topaz responded very uniformly to the penetrating rays from 200 mgs. Ra, though more slowly than rock salt, sapphire, and kunzite. In about a month a brownish amber color was produced which was uniform in all the specimens examined. Smoky topaz deepened in its own shade. The colors produced in topaz are apparently light-permanent. Neither fluorescence nor thermophosphorescence was observed.

*Garnet.*—Three specimens of deep red garnet acted uniformly in undergoing a reduction in color by the penetrating rays from 200 mgs. Ra, the color changing from deep red to violet, or purple. The color change produced is apparently light-permanent. No fluorescence nor thermophosphorescence was observed.

*Quartz.*—A fairly large number of specimens of different varieties of quartz was examined. In most cases the smoky color, characteristic of some varieties of natural quartz, is produced by radiation either from an initial colorless or by deepening a light smoky color or by changing the amethystine or rose color to smoky. A few failures to produce any color in colorless quartz by 200 mgs. Ra in one month were encountered.

In some cases radiation of light amethyst deepens the amethystine color, in other cases it changes to the smoky color. Continued failure to produce amethystine color in colorless quartz suggested the following test: A crystal of amethystine quartz was decolorized by heating in air to a dull red. After cooling, it was exposed to the penetrating radiation from 200 mgs. Ra which gradually restored the amethystine color, and after several months carried it to a much deeper amethystine shade than the original. While quartz is not fluorescent, either under penetrating or alpha radiation, most specimens show a marked thermophosphorescence of bluish-white or bluish-green shade, which is quite persistent and equal in brilliancy to that of fluorspar. Other specimens of milky quartz and amethystine quartz showed no thermophosphorescence following radiation, though both were decolorized under heating.

*Tourmaline.*—Two specimens of tourmaline, one pink, and one green, showed no change in color under penetrating radiation. The green tourmaline failed to fluoresce or to change color in ten days' exposure to an initial quantity of 150 millicuries of emanation, and later failed to show any thermophosphorescence up to 300° C. The pink specimen was examined only with respect to coloring by penetrating radiation.

*Diamond.*<sup>5</sup>—More than thirty specimens of cut diamonds, supposed to represent the principal diamond fields of the world, varying in size from a fraction of a carat to ten carats and in color from colorless to yellow and caramel brown, were examined. Fluorescence under penetrating radiation from a very thin tube

<sup>5</sup> For fuller details, see paper by the same authors which will appear in a later issue of this JOURNAL.



containing 60 mgs. Ra could not be detected. Fluorescent response to alpha radiation in the emanation tubes was universal and very sensitive. The color of the fluorescent light in emanation varied for different specimens from green to bluish-green to greenish blue to blue without any regularity with reference to the color of the diamond itself. For the same specimen the color of fluorescence varied somewhat with conditions as to intensity of radiation and gas pressure in the emanation tube (perhaps the latter only as effecting the former). Fluorescence was also observed near a thin alpha-ray bulb containing emanation.

Prolonged exposure (one month) to *penetrating rays* from 250 mgs. Ra failed to produce any change in color in five yellow Cape diamonds of four to ten carats. But prolonged exposure (45 to 75 days) to *alpha radiation*, either directly in 10 to 50 per cent.  $\text{RaCl}_2$  salt or in emanation, produced universally a green color, which deepened with time (or with intensity of radiation) through grass green to a dark sage green. These results confirm that of Sir William Crookes<sup>6</sup> and met with no exception in all the more than thirty specimens treated. Colorless and yellow diamonds seem to take equally perfect green. Brown diamonds were off shade toward olive probably due to superimposed brown. The color is apparently light-permanent but can be discharged by heating to 450° C. for about an hour and in a shorter time at higher temperatures, or more slowly at lower ones. By interrupting the heating any intermediate shade of green can be obtained. The original color is finally restored by continued heating. The puzzling question as to the depth of the penetration of the colored layer, and the appearance in some specimens of "carbon spots" will be considered in the following paper devoted exclusively to the diamond.

*Chrysoprase*, *opal* and *other opaque minerals* showed no color change. This seemed to be a general characteristic of the opaque minerals. Upon heating chrysoprase after exposure to emanation, no light effects were observed, but a surface discoloration was produced which destroyed the natural lustre of the cut stone.

*Aquamarine* (light green), *zircon* (almost colorless), *peridot* (light green), and *moss agate* exhibited neither color change nor luminous phenomena. Aquamarine was exposed to penetrating radiation from 210 mgs. Ra for almost two years without changing hue in the slightest.

<sup>6</sup> Sir Wm. Crookes, *Phil. Tr. Roy. Soc.*, 214A, 433-45 (1905); *Sci. American*, Supplement No. 2270 (July 5, 1919).

## DISCUSSION OF RESULTS AND THEORY

The foregoing observations make no pretense to completeness, but are rather intended to show the complexity of the phenomena exhibited by the various transparent minerals and gems with respect to coloring and the emission of fluorescent and phosphorescent light, and to illustrate the difficulties that are encountered in attempting to propose a satisfactory theory. One is confronted with a most confusing complexity of relations and almost every possible combination is met. On the one hand, we have minerals like aquamarine and peridot which show a negative behavior throughout toward the radium radiations, being neither colored nor excited to any light emissions. Again, at the other extreme, we have a few minerals like kunzite and fluorspar which always exhibit in marked degree the phenomena under consideration. Among different specimens of the same mineral, we also have all extremes of behavior from complete regularity to almost complete variability. Such variable behavior has generally been regarded and, in the opinion of the writers, is properly regarded as pointing to the presence in certain minerals of *impurities* which are mainly responsible for their behavior during the following radiation. In those minerals, on the other hand, where no irregularity of behavior is observed, one is forced to the conclusion that the phenomena exhibited are due to properties inherent in the mineral itself.

That the presence of impurities, sometimes in minute quantities, plays a rôle in a variety of phenomena connected with coloring and light emission has been known for some time. It has been recognized in the case of phosphorescent alkaline earth sulphides, in the fluorescent-phosphorescent zinc sulphides, in the natural coloring of minerals, in the color produced in minerals by radiation, in the triboluminescence of natural zincblende (which must contain iron or manganese to show triboluminescence), and in many other related phenomena.

The following appeals to us as a simple and plausible general theory.<sup>7</sup> Certain groups of *electrons* are displaced by radiation from their normal positions and take up new metastable positions

<sup>7</sup> The possibility of a theory based on a change in the mode of electronic "binding" (Bindungsweise) was mentioned in the earliest paper of Meyer and Przibram (*Sitzb. Akad. Wiss. Wien*, **121**, IIa, 1416, (1912), but was not further elaborated nor mentioned in their subsequent papers.



among the atoms. No displacement (or only secondary displacement) of the atom is involved. No change in the crystal lattice as revealed by X-rays would be expected nor would there be any production of colloidal particles. One or more groups of electrons may be involved. By *group* is meant a number of electrons all having uniform positions in the original atoms from which they are displaced and taking after displacement uniform new positions among the other atoms.

In cases where two or more groups are involved, the return of one group to the original position may cause thermophosphorescent effects, the return of a different group may cause decolorization. This does not preclude the possibility that a single group may bring about both phenomena, thus rendering them absolutely coincident. On the other hand, the possibility is evident that the two may be entirely independent, each having a different energy index or either one may be entirely lacking, as we have shown to be the case for certain minerals.

Our assumption is that these electrons are removed by radiation to abnormal positions in which their constraints are lessened so that they vibrate with a frequency which may, and frequently does, fall in the visible region. Since the crystal is transparent the color complementary to the one absorbed by the electronic vibration is transmitted. In the metastable positions, under less constraint, the electrons are also freer to take part in electrical conduction and in photo-electric emission under radiative stimulus, and can also return to their normal positions under this stimulation or by that of heat.

Color-saturation would then be reached under continued radiation when the number of electrons returning to normal positions just equals the number being displaced. Upon cessation of radiation the electrons in abnormal positions may either remain indefinitely in the metastable position or may return gradually to their normal positions. The latter action will be brought about more rapidly by the stimulation of heat or some form of radiation of sufficient intensity to displace electrons from their abnormal positions without causing others to be driven from normal positions. One set of electrons may slowly revert, while another set remains indefinitely displaced.

The influence of impurities, in the light of this theory, may be one or both of the following: (1) To loosen electrons so that they

are more readily displaced. Again this effect may be due (a) to an effect exerted only on the electrons of the original atoms, or (b) by the formation of complexes from which the electrons are more readily displaced than from normal atoms. (2) The influence exerted by the impurities may be exerted on the electrons after liberation, in holding them more firmly in the abnormal positions, or both (1) and (2) may act jointly in some cases. The presence of an impurity may not be essential in all substances to the electronic displacements under consideration.

We can find in the present results very little support for the theory that colored minerals in nature have been colored by the action of the earth's radioactivity. If this were the case for diamonds, for example, we should expect to find in nature many *green diamonds*, since this has been shown to be the commonest (and in our experiments the only) color produced by radium radiation; but actually *green* is a very rare color in natural diamonds. Furthermore, the artificial colors, even when similar to the natural ones, appear to be much less permanent with respect to heat and often with respect to light.

On the basis of the present theory the actual proportion of color-producing electrons to the total number of atoms in a given slightly colored mineral must be quite small. It is calculated from ionization by penetrating radiation that the fraction in rock salt just noticeably colored is of the order  $10^{-5}$ . Accordingly the quantity of energy necessary to produce (and even more so to discharge) color is surprisingly small in some cases. In general, it may be stated that the colors which are most easily produced are also most easily discharged and *vice versa*.

While it may be objected that the theory here proposed is not very definite and has not been quantitatively supported, it appears to us that it is capable not only of explaining the phenomena under consideration, but also has the necessary elasticity to fit the various other phenomena which are encountered and which must be explained. A more quantitative support must await a more intimate knowledge of atomic structure and of the properties of electrons and ions within that structure.



## THE IDENTITY OF EAKLEITE AND XONOTLITE

ESPER S. LARSEN,<sup>1</sup> *Harvard University*

In 1917 I described a hydrous calcium silicate from California for which the name eakleite was proposed.<sup>2</sup> Dr. Schaller has recently called my attention to the fact that chemically eakleite is identical with the previously described mineral xonotlite, and a study of the other properties of xonotlite and comparison with those of eakleite show clearly their identity.

The six available analyses of xonotlite, including those that were called eakleite, shown in the following table, bring out the chemical identity of all the specimens.

ANALYSES OF XONOTLITE

	1	2	3	4	5	6	7
SiO <sub>2</sub>	49.58	50.25	48.91	50.17	50.80	50.96	50.16
Fe <sub>2</sub> O <sub>3</sub>	—	—	—	1.04	1.32	—	—
FeO	1.31	2.28	2.97	—	—	1.69	—
MnO	1.79	—	2.27	—	—	1.40	—
CaO	43.56	43.92	40.39	45.45	42.88	36.72	46.82
MgO	—	0.19	0.56	tr.	1.10	0.37	—
Na <sub>2</sub> O	—	—	0.22	none	0.55	4.41	—
H <sub>2</sub> O—	3.70	4.07	4.17	3.18	0.12	2.74	3.02
H <sub>2</sub> O+					3.68		
	99.94	100.71	100.76	99.84	100.53	99.39	100.00
Sp. Gr.	2.710	2.718	2.605	2.70			

1 & 2. Tetela de Zonotla, Mexico, analysis by Rammelsberg, quoted from Dana.

3. Scotland—analyses by Heddle quoted from Dana. Contains Al<sub>2</sub>O<sub>3</sub> 0.11, K<sub>2</sub>O 1.16.

4. "Eakleite," California. Average 2 analyses by Eakle, on very pure material. *Am. J. Sc.*, **43**, 465, (1917).

5. "Eakleite," Isle Royal, Michigan, Analyses by Foshag. Contained a few per cent of chlorite. *Am. Min.*, **7**, 24, (1922).

6. Natroxonotlite, near Magnet Cove, Ark. Analyses by Brackett, quoted from Dana. Contains K<sub>2</sub>O 0.90.

7. Theoretical for 5 CaO.3 SiO<sub>2</sub>.H<sub>2</sub>O

The optical and other physical properties have been measured on specimens from three localities and they show not only the

<sup>1</sup> Published with permission of the Director of the U. S. Geological Survey.

<sup>2</sup> Larsen, Esper S., Eakleite, a new mineral from California; *A. J. Sc.* **43**, 464-5, (1917).

identity of eakleite with xonotlite, but a remarkable uniformity in the optical properties of specimens from various localities.

## OPTICAL PROPERTIES OF XONOTLITE

	1	2	3
$\alpha$	1.583	1.579	1.581
$\beta$	1.583		
$\gamma$	1.593	1.590	1.591
2V	very small	small	small
Opt. char.	+	+	+
Elongation	Z	Z	Z

1. "Eakleite," California, Larsen.

2. "Eakleite," Isle Royal, Mich., Larsen.

3. Xonotlite, Tetela de Zonotla, Mex. New data by Larsen.

The name xonotlite has priority and should be retained for the species. From all the localities the xonotlite is in matted fibers of white, gray, or pale pink color, and great toughness. Xonotlite has a specific gravity of about 2.70. It is decomposed in acid with separation of pulverulent silica. It fuses at about 2.5.

Xonotlite appears to be a relatively common mineral as, in addition to the localities described above, I have found it in specimens submitted for identification from Mine Center, Minn.

BARRANDITE FROM MANHATTAN, NEVADA<sup>1</sup>

EARL V. SHANNON, *U. S. National Museum*

A shipment of specimens recently received at the National Museum from Mr. H. G. Clinton of Manhattan, Nevada, contained a mineral labeled "yellow turquoise" which appeared unusual in character and, since a large number of aluminium phosphates are under examination in this laboratory, it was subjected to an analysis. The results of this investigation, as presented below, identify the mineral as barrandite, a hydrated phosphate of iron, probably the ferric iron analogue of variscite and which has, hitherto, been known only from the original locality which is Prizibram, Bohemia. The locality is Manhattan and the label gives the additional information that the mineral occurs "in lime-rhyolite contact with vashegyite and utahlite."

The mineral forms a filled seam occupying an irregular crack averaging 5 mm. in width with small side branches and spurs. The matrix is an indeterminate rock of dark gray color having shaly

<sup>1</sup> Published by permission of the Secretary of the Smithsonian Institution.



partings coated with a whitish clayey substance. Small flakes of the matrix occur as inclusions in the phosphate.

In the specimen examined the barrandite appears amorphous and opaque with a faint waxy luster. In general the appearance is quite similar to that of a brown jasp-opal with smooth, imperfectly conchoidal, flinty fracture. It is very brittle and tends to disintegrate with the formation of contraction cracks. The body color is between olive ocher and Isabella color (Ridgway), although the color deepens toward the borders, and in the smaller seams trends toward a rich golden brown and the mineral becomes more translucent. Fragments without visible gangue are found by microscopic examination to be essentially pure and, like the utahlite variety of variscite, very finely holocrystalline, the grains being entirely too small to permit of determination of the optical properties other than mean index of refraction, 1.640, and birefringence, 0.020, which are in agreement with the values found by Larsen for the original barrandite which had a mean index of 1.650 and a birefringence of 0.030.

The mineral has a hardness slightly above 2.0. It is completely soluble in hot hydrochloric acid but is insoluble in nitric acid. The analysis yielded the following composition:

## ANALYSIS AND RATIOS OF BARRANDITE FROM NEVADA

CONSTITUENT	PER CENT		RATIOS	
SiO <sub>2</sub>	1.12			
Al <sub>2</sub> O <sub>3</sub>	8.15	.030 }		
Fe <sub>2</sub> O <sub>3</sub>	30.00	.188 }	.268×1	.96×1
P <sub>2</sub> O <sub>5</sub>	36.29	.256 }	.256×1	.91×1
CaO	1.20	.021		
FeO	.90	.013 }		
MgO	1.36	.034 }	.291×4	1.03×4
H <sub>2</sub> O+110°C.	19.72	1.095 }		
H <sub>2</sub> O-110°C.	1.88	.104		
<hr/>				
	100.62			

The ratios are thus in fair agreement with the formula originally given for barrandite, namely, (Fe,Al)<sub>2</sub>O<sub>3</sub>.P<sub>2</sub>O<sub>5</sub>.4H<sub>2</sub>O. The water below 110° is considered hygroscopic since it is present in amounts less than half a molecule and seems to be separated by a considerable temperature interval from the main bulk of the water. If it be included the ratios give nearly 5H<sub>2</sub>O. The bivalent bases are here included with the water ratios rather than with the trivalent

oxides, it being assumed that the composition of the mineral can be expressed as  $\text{H}_2\text{FePO}_3 \cdot \text{H}_2\text{O}$ , the bivalent bases occurring in replacement of the basic hydrogen. These bases may in part exist as extraneous or adsorbed constituents in such a fine grained material of evidently metacolloidal character, or may possibly be in part combined with the silica. That the mineral is to be referred to barrandite is shown by its optical properties which are quite distinct from those of strengite (mean index above 1.70) and koninckite (isotropic).

## PROCEEDINGS OF SOCIETIES

### PHILADELPHIA MINERALOGICAL SOCIETY

*Academy of Natural Sciences, June 14, 1923.*

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, Mr. Harry W. Trudell presiding in the absence of Mr. Geo. Vaux. In the absence of the Secretary, Mr. J. C. Boyle assumed the Secretary's place *pro tem*. Fifteen members were present.

The minutes of the previous meeting were read and approved. Mr. Jos. L. Darlington, of West Chester, Pa. was proposed for membership by Mr. Biernbaum, and seconded by Mr. Horace Hallowell. Several excursions were proposed by Mr. Oldach, as follows: Perkiomenville, Wood's Chrome Mine, and Feeney's Quarry, at Holland, Pa.

Mr. Hoadley reported the digging of a water tunnel by the Newark Water Co. near Great Notch, N. J. which passes under the floor of the old Francesco Quarry. The minerals from the new boring are the same as formerly found at the Quarry; gmelinite, calcite, heulandite, stilbite, amethyst, smoky quartz, prehnite. Mr. Hoadley also reported that the New York Club had found autunite, hyalite and yellow beryl at the second Kunkle Quarry, Bedford, N. Y. on May 30th last. Mr. Vanardsdalen stated that Feeney's Quarry seemed a good prospect at present and that while the Jarrett Quarry was being worked nothing was found worthy of comment. Mr. Hoadley stated that brucite of superb quality, crystallized, had been found several winters ago in the excavation for the New York Stock Exchange Annex. Mr. Blank exhibited hornblende from Rock Hill Quarry near Quakertown, Pa., which was accompanied by an undetermined microscopic mineral. Mr. Millson reported being at Perkiomenville on May 30th but found little of interest as the recent blast had covered what minerals were usually found near the bottom of the Quarry. Mr. Keeley exhibited fine specimens of blue tourmaline from Andover, Maine, purchased for the Vaux Collection, as well as kunzite crystals for the same collection. He stated he had received a letter from the Pennsylvania State Geological Survey, requesting specimens of cut stones of Pennsylvania minerals, and asked for whatever good material the members cared to furnish.

The trip to French Creek on May 27th and 28th was reported upon by various members; Mr. Oldach reported having secured an octahedron of pyrite of good size, considerable chalcopyrite crystals in blocks of byssolite, and apophyllite.



He stated he had secured three varieties of this mineral from French Creek, out of a possible four mentioned in Dana. One variety seemed to consist of concentric layers.

Mr. Hoadley reported chalcodite in feldspar and a pyrrhotite crystal with two pinacoids and all but one prism face; also attractive pyrite. Report was also made of the trip down the mine to the 1250 foot level. Mr. Trudell made especial reference to this trip and Mr. Maddern, who accompanied the party, presented an interesting geological sketch and explanation of the practical mining problems.

Commenting on the subject of French Creek Minerals, Mr. Keeley reported having found, about 40 years ago, elongated octahedrons of pyrite. In the discussion of apophyllite, Mr. Keeley stated that under polarized light, crystals with concentric structure, cleaved parallel to the base, show wedges of color like andalusite. This seems characteristic of this variety and the same phenomenon is present in Brazilian topaz. The impression conveyed is that of inter-penetrating twinning, but seems to be due to a tendency of the mineral to change its crystal structure after crystallization.

Mr. Biernbaum, reporting upon various localities, stated that the Springfield Quarry was "dead," while Leipers showed promise in the upper levels, but on his visit yielded nothing but a broken beryl. Dutton's Mills yielded two small doubly terminated amethysts and a few fragments; Brinton's he reported as "dilapidated." Mr. Keeley called attention to the granite dyke at Brinton's as being of an unique type, as it is entirely free of dark colored minerals. Mr. Hoadley mentioned an interesting outcrop of fine grained nepheline syenite at Beamerville N. J. above Franklin, which parallels the Kittatiny Range for a mile and is about three quarters of a mile wide. The rock at the surface is rust covered and contains numerous fumaroles. No large crystals have been seen in this formation, but the whole section is reported as being very interesting, geologically.

A letter from Dr. Washington was read, expressing his hearty enjoyment of his trip to Philadelphia in May and his pleasure in addressing the Society and meeting its members. No further business being offered, the Society adjourned.

J. C. BOYLE, *Secretary pro tem.*

FURTHER ADDITIONS TO LIST OF MINERALS DESCRIBED OR DISCREDITED  
DURING 1916-1920

"Daiton-sulfur" . . . . .	S	Var. of Sulfur, monoclinic	7, 213
"Rubber-sulfur" . . . . .	S	Var. of Sulfur, amorphous	7, 213
Guadalcazarite . . . . .	HgS	Crystallographically distinct	5, 37
(unnamed) . . . . .	Co <sub>2</sub> As <sub>2</sub>	Mineragraphically distinct	7, 18
(unnamed) . . . . .	sulfo-salt	Crystallographically distinct	7, 213
"Pseudo-mendipite" . . . . .	halide	Existence undemonstrated	7, 213
Nocerite . . . . .	Mg <sub>2</sub> Ca <sub>2</sub> F <sub>2</sub> O <sub>2</sub>	Redefined	8, 116
"Iron-pyrochroite" . . . . .	(Mn, Fe) (OH) <sub>2</sub>	=ferriiferous pyrochroite	7, 214.
"Paraaurichalcite" . . . . .	carbonate	= zinciferous malachite	7, 180
"Cuprozincite" . . . . .	carbonate	= zinciferous malachite	7, 181
"Manganese chalcantite" . . . . .	Mn (SO <sub>4</sub> ) (H <sub>2</sub> O) <sub>2</sub>	A new "co-species"	7, 75
"Cobalt chalcantite" . . . . .	Co (SO <sub>4</sub> ) (H <sub>2</sub> O) <sub>2</sub>	A new "co-species"	7, 75
"Iron-copper chalcantite" . . . . .	(Fe, Cu) (SO <sub>4</sub> ) (H <sub>2</sub> O) <sub>2</sub>	A new "co-species"	7, 75
"Zinc-copper chalcantite" . . . . .	(Zn, Cu) (SO <sub>4</sub> ) (H <sub>2</sub> O) <sub>2</sub>	A new "co-species"	7, 74
Zinc-copper melanterite . . . . .	(Zn, Cu) (SO <sub>4</sub> ) (H <sub>2</sub> O) <sub>2</sub>	A new species	7, 74
"Hydro-glocherite" . . . . .	Fe <sub>2</sub> SO <sub>4</sub> (H <sub>2</sub> O) <sub>2</sub>	Indefinite	7, 214
(unnamed) . . . . .	(NH <sub>4</sub> ) (NO <sub>3</sub> )	Inadequately described	6, 68
Meta-torbernite I. . . . .	Cu (UO <sub>2</sub> ) <sub>2</sub> (PO <sub>4</sub> ) <sub>2</sub> (H <sub>2</sub> O) <sub>2</sub>	Recognized in nature	8, 115
(unnamed) . . . . .	Al <sub>2</sub> F <sub>2</sub> P <sub>2</sub> O <sub>12</sub> (H <sub>2</sub> O) <sub>2x</sub>	A new species	7, 178
"Parabayldonite" . . . . .	arsenate	Impure bayldonite	7, 181
"Cuproplumbite" . . . . .	arsenate	Impure bayldonite	7, 181
Torendrikite . . . . .	amphibole	A new species	7, 212
Shattuckite . . . . .	Cu <sub>2</sub> (SiO <sub>3</sub> ) <sub>2</sub> (H <sub>2</sub> O)	Redefined	4, 62
"Cacoclasite" . . . . .	garnet	A pseudomorph	5, 44
"Fluor-meionite" . . . . .	scapolite	Homogeneity doubtful	7, 214
"Iochroite" . . . . .	tourmaline	Var. of ordinary tourmaline	6, 70
"Calcibiotite" . . . . .	mica	= calciferous biotite	7, 214
"Wodanite" . . . . .	mica	= titaniferous biotite	7, 197
"Gavite" . . . . .	talc	= high-water talc	4, 132
"Magnalite" . . . . .	clay	= mixture of colloids	8, 189
"Fluosiderite" . . . . .	silicate	= composition unknown	8, 189

The above table is supplementary to lists published in *Am. Min.*, 6, (1), 12-17, and 6, (12), 176, (1921).

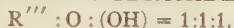
## NEW MINERAL NAMES, 1916-1920

"Barium-hamlinite" . . . . .	= variety of hamlinite	"Manganoferrite" . . . . .	= jacobsite
"Basalt-kainite" . . . . .	= anhydrosainite	"Metaparisite" . . . . .	= altered parisite
"Bayate" . . . . .	= jasper	"Nickel-linneite" . . . . .	= polydymite
"Calc-clinoenstatite" . . . . .	= enstatite-augite	"Oakermanite" . . . . .	= âkermanite
"Calc-clinobronzite" . . . . .	= bronzite-augite	"Pizite" . . . . .	= picite
"Calc-clinohypersthene" . . . . .	= hypersthene-augite	"Pleysteinite" . . . . .	= kreuzbergite
"Cobalt-melanterite" . . . . .	= bieberite	"Pseudopyrochroite" . . . . .	= baekstroemite
"Copper-melanterite" . . . . .	= boothite	"Scleroclasite" . . . . .	= scleroclase
"Ferri-gehlenite" . . . . .	= a possible end-species	"Selenobismuthite" . . . . .	= selenowismuthglanz
"Ferri-sarcolite" . . . . .	= ferric-iron sarcolite	"Siderazotite" . . . . .	= siderazote
"Ferrochromite" . . . . .	= chromite	"Silver-jamesonite" . . . . .	= owyheeite
"Ferroferrite" . . . . .	= magnetite	"Talc-spinel" . . . . .	= spinel
"Fluor-diopside" . . . . .	= fluoriferous diopside	"Tellurobismuthite" . . . . .	= tellurwismuth
"Fluormanganapatite" . . . . .	= var. of fluorapatite	"Titanbiotite" . . . . .	= wodanite
"Glaucodotite" . . . . .	= glaucodote	"Titanhydroclinochumite" . . . . .	= var. of clinohumite
"Makensite" . . . . .	= mackensite	"Zincoferrite" . . . . .	= franklinite. E. T. W



## NEW MINERALS: DOUBTFUL SPECIES

CLASS: OXIDES AND HYDROXIDES. DIVISION:

**"Kayserite"**

KARL WALTHER: Die Bildung des Schmirgels, betrachtet an einem Vorkommen von Korundfels in Uruguay. (The formation of emery, considered in an occurrence of corundum rock in Uruguay.) *Z. Deutsch. Geol. Ges.*, A, 73, (4), 292-338, 1921; this mineral, p. 316.

NAME: In honor of Professor Emanuel Kayser.

CHEMICAL PROPERTIES: *Formula*,  $AlO(OH)$ . Theory (taking the at. wt. of Al as 27.0)  $Al_2O_3$  85.0,  $H_2O$  15.0%. Analysis gave:  $SiO_2$  3.13,  $Al_2O_3$  81.24,  $Fe_2O_3$  1.01,  $MgO$  0.34,  $H_2O$  105°—0.05,  $H_2O$  105°+14.70, sum 100.47%.

CRYSTALLOGRAPHIC AND OPTICAL PROPERTIES: To be regarded as monoclinic because extinction is inclined, up to 46°, on some cross sections of crystals, but parallel to the edges on others. Refractive index  $\alpha$  somewhat above 1.68,  $\gamma$  below 1.74, double refraction about 0.055. Axial angle large;  $v > \rho$ . It is therefore a dimorphic form of the compound, the orthorhombic form of which is known as diaspore.

PHYSICAL PROPERTIES: Crystalline, with micaceous cleavage; brittle; hardness 5-6.

OCCURRENCE: A secondary formation on corundum crystals from Cerro Redondo, Minas, Uruguay.

DISCUSSION: While the evidence of the distinctness of this material is fairly good, somewhat better optical data and if possible some crystallographic measurements should be obtained before its status can be regarded as firmly established.

E. T. W.

CLASS: SULFATES. DIVISION:  $R''' : SO_3 : H_2O = 2 : 1 : 3$ .**"Borgstroemite"**

M. SAXÉN: The geology of the Otravaara ore field. *Medd. Geol. Fören. Helsingfors*, 1919-1920, 17-21; thru *Min. Abstr.*, 2, 10. (Original not seen.)

NAME: After the Finnish mineralogist L. H. Borgström.

CHEMICAL PROPERTIES: *Formula*,  $Fe_2O_3 \cdot SO_3 \cdot 3H_2O$ .

PHYSICAL PROPERTIES: Color yellow; structure earthy.

OCCURRENCE: Formed by surface weathering of pyrite and pyrrhotite in Eno parish.

DISCUSSION: More data necessary before the distinctness of this mineral can be regarded as established.

E. T. W.

CLASS: PHOSPHATES, ETC. DIVISION: (UNDETERMINED)

**"Rauvite"**

FRANK L. HESS: Uranium-bearing asphaltite sediments of Utah. *Eng. Mining J.-Press*, 114, 272-276, 1922; this mineral, p. 274.

CHEMICAL PROPERTIES: A new calcium uranium vanadate.

OCCURRENCE: At Temple Mountain, Utah.

DISCUSSION: Inclusion of this in classified lists of minerals will have to await publication of descriptive data.

E. T. W.

## CLASS: SILICATES. DIVISION: (CLAYS).

## "Magnalite"

S. RICHARZ: Die Basalte der Oberpfalz (The basalts of the Oberpfalz). *Z. Deutsch. Geol. Ges.*, A, **72**, 31-36, 1920; *Z. Krist.*, **57**, 587, 1923.

NAME: From the composition, *magnesium-aluminium* and *lithos*, stone.

CHEMICAL PROPERTIES: *Composition*, SiO<sub>2</sub> 42.17, Al<sub>2</sub>O<sub>3</sub> 17.48, FeO 1.49, CaO 3.38, MgO 10.71, K<sub>2</sub>O 0.76, Na<sub>2</sub>O 1.38, H<sub>2</sub>O 14.01, H<sub>2</sub>O + 5.95, CO<sub>2</sub> 2.64, sum 99.97%.

PHYSICAL PROPERTIES: Color dull green to nearly white; soft with greasy feel;  $d=2.34$ . Under the microscope nearly amorphous with some radiating fibers.

OCCURRENCE: In cavities in basalt from the Oberpfalz.

DISCUSSION: Homogeneity not demonstrated, and seems obviously a mixture, unworthy of a name. E. T. W.

## REDEFINITION OF SPECIES

## CLASS: SILICATES. DIVISION: (UNDETERMINED).

## "Fluosiderite"

A. SCACCHI, 1881; redefined by F. ZAMBONINI: The pipernoid tuffs of Campania and their minerals. *Mem. serv. descr. carta geol. Ital.*, **7**, pt. 2, 105 115, 1919; thru *Z. Krist.*, **57**, 219, 1922; (original not seen).

CHEMICAL PROPERTIES: Qualitative tests show Ca, Mg, some Al, a little Fe and Mn, and Si; H<sub>2</sub>O may be present. The name is thus rather inappropriate.

CRYSTALLOGRAPHIC PROPERTIES: Orthorhombic;  $a:b:c=0.3479:1:0.3203$ . Forms:  $b$  (010),  $m$  (110),  $g$  (130),  $l$  (350),  $- (1.10.0)$ ,  $d$  (021),  $o$  (111),  $t$  (112),  $p$  (132),  $q$  (152), and  $r$  (172). Combinations and habit variable; other orientations are suggested.

PHYSICAL AND OPTICAL PROPERTIES: Pleochroism,  $\perp c$  brown red,  $\parallel c$  brighter.

OCCURRENCE: Found in the tuffs of the Campania.

DISCUSSION: More data needed to establish and classify this mineral satisfactorily. E. T. W.

## ABSTRACTS: CRYSTALLOGRAPHY

THE CRYSTAL STRUCTURE OF SODIUM NITRATE. R. W. G. WYCKOFF. *Phys. Rev.*, **16**, 149-57, 1920.

From Laue photographs it was found that NaNO<sub>3</sub> has a body-centered unit rhombohedron containing two molecules. The arrangement of the atoms in the crystal as a whole resembles that of the NaCl crystals, with NO<sub>3</sub> in the place of Cl.

E. F. H.

CRYSTAL ANALYSIS OF METALLIC OXIDES. W. P. DAVEY AND E. C. HOFFMAN. *Phys. Rev.*, **15**, 333, 1920.

CaO, MgO, CdO, and NiO are cubic with the NaCl structure. Al<sub>2</sub>O<sub>3</sub> has a structure similar to that of calcite.

E. F. H.

NEW METHOD FOR X-RAY CRYSTALLOGRAPHY OF PULVERIZED SUBSTANCES. H. BOHLIN. *Ann. Physik*, **61**, 427-39, 1920.

This is an improvement on Debye and Scherrer's method, giving much sharper spectral lines. Al, Th, Ni, and Mg were studied by this method. E. F. H.

OPTIC AND ELECTRIC AXES OF SYMMETRY IN MONOCLINIC CRYSTALS. H. RUBENS. *Z. Physik*, **1**, 11-31, 1920.

The optic axes when  $\lambda=0.3\text{mm}$ . (Hg vapor radiations) agree well with the electric axes. Adularia, augite, gypsum, and sugar were studied. E. F. H.

VALENCY FORCES IN THE BUILDING OF CRYSTALS. H. THIRRING. *Z. Elektrochem.* **26**, 281-6, 1920.

Besides the electrostatic forces existing between the ions which occupy the points of a xl. structure, there must be repulsive forces, which may be supplied by electronic movements. E. F. H.

ELECTROSTATIC POTENTIAL OF THE FLUORSPAR LATTICE. E. BORMANN. *Z. Physik*, **1**, 55-6, 1920.

New theoretical determinations are made for  $\text{CaF}_2$ ,  $\text{CaCl}_2$ ,  $\text{CaBr}_2$  and  $\text{CaI}_2$ .

E. F. H.

THE POSSIBLE EXISTENCE OF BINDING RINGS IN DIAMOND. N. H. KOLKMEIJER. *Proc. k. Akad. Amsterdam*, **23**, 120-8, 1920.

A confirmation, from a study of X-ray spectra, of Debye and Scherrer's conclusion that binding rings of electrons do not exist between the C atoms in the diamond. E. F. H.

THE NATURE OF CRYSTAL CLEAVAGE: G. WULFF. *Phys. Z.*, **21**, 718-20, 1920.

The cleavages of fluorite, sphalerite, diamond, calcite, and sulfur are considered from the standpoint of cohesion forces as deduced from the crystal structures determined by X-ray methods. E. F. H.

THE BRAGG CRYSTAL LATTICE AND CLEAVAGE. RUDOLF SCHARIZER. *Z. Kryst. Min.*, **55**, 440-3, 1920.

The cleavages of diamond, fluorite, pyrite, sphalerite, and halite are studied in connection with the space-lattices as determined by the Braggs. Cleavage takes place parallel to groups of lattice planes if these contain like atoms. If the lattice planes are equally distant, they must be similarly constituted, in order to have cleavage parallel to them. In case of several possibilities, cleavage is parallel to the plane with the greatest reticular density. E. T. W.

THE LATTICE-PLANES IN ISOMETRIC CRYSTALS. F. HAAG. *Z. Kryst. Min.*, **55**, 444-53, 1920.

This is a mathematical discussion in which Bragg's results for halite, diamond and pyrite are substantiated. E. T. W.



NEW ATTACHMENTS FOR THE POLARIZING MICROSCOPE. M. BEREK. *Z. Kryst. Min.*, **55**, 615-26, 1920.

Convenient arrangements of Bertrand lenses and iris diaphragms for the study of interference figures, and an improved Fedorov universal stage are described.

E. T. W.

1-HYDROXY-2-BENZOYL CAMPHOR. A. L. VAN DER VEEN. *Z. Kryst. Min.*, **55**, 627, 1920.

A complete optical and crystallographic description is given. The substance is orthorhombic bisphenoidal.

E. T. W.

MIXED CRYSTALS OF *P*, *P'* -DICHLORO-, -DIBROMO- AND -DIMETHYLBIPHENYL. K. MIELEITNER. *Z. Kryst. Min.*, **55**, 631-4, 1920.

Crystallographic data for these substances is given, and striking relationships are shown.

E. T. W.

THE PICRATES OF THE NITROGEN BASES OF THE ALCOHOL RADICALS. A. RIES. *Z. Kryst. Min.*, **55**, 454-522, 1920.

Complete crystallographic descriptions and transition data are given of 31 compounds, including substituted ammonium picrates, secondary, tertiary and quaternary amines.

E. T. W.

## MINERALOGY

MAGNETIZATION AND HYSTERESIS IN HEMATITE CRYSTALS. T. T. SMITH. *Phys. Rev.*, **15**, 345-64, 1920.

This paper presents some results obtained by measuring the couple exerted when a hematite crystal is suspended in a uniform magnetic field.

E. F. H.

REPORT FROM THE CHEMICAL LABORATORY OF THE ROYAL HUNGARIAN GEOLOGICAL SURVEY. BÉLA HORVÁTH. *A. Magyar Kir. Földtani Intézet évi Jelentése*, 1916 for 1915, 471-86; 1917 for 1916, 511-39; thru *Mineralog. Abstr.*, **1**, 385.

Four analyses of Hungarian bauxites and one of a feldspar are given. E. F. H.

THE COEFFICIENTS OF THERMAL EXPANSION OF MINERALS AND STONES AND ARTIFICIALLY PREPARED SUBSTANCES OF SIMILAR COMPOSITION. KARL SCHULZ. *Fortsch. Min. Krist. Petr.*, **4**, 337-84, 1914; **5**, 293-324, 1916; **6**, 137-206, 1920; **7**, 327-426, 1922; thru *Mineralog. Abstr.*, **1**, 368.

This is a summary of the literature and compilation of data.

E. F. H.

THE OCCURRENCE OF BINDHEIMITE AS AN ORE MINERAL. EARL V. SHANNON. *Econ. Geol.*, **15**, 88-93, 1920.

Bindheimite, a hydrous antimonate of lead, hitherto regarded as comparatively rare is shown to be a common constituent of many oxidized lead ores and to be of widespread occurrence. It frequently occurs as a soft yellow ocher resembling ochreous limonite with which it is often associated. At other times it appears to be pseudomorphous after jamesonite.

W. F. H.

RARE ZINC-COPPER MINERALS FROM THE RHODESIAN BROKEN HILL MINE, NORTHERN RHODESIA. E. P. MENNEL. *Mineral. Mag.* 19, (90), 69-72, 1920.

The copper minerals of this region include malachite, chessylite, cuprite, chalcocite, undetermined phosphates and double salts of copper and zinc (aurichalcite). The copper phosphates occur as greenish or bluish incrustations often mixed with parahopeite. About 1 g. of crystals of one of these rare minerals was collected and the following properties noted: Monoclinic,  $\beta$  about  $76^\circ$ , with deep ultramarine blue color. Transparent and non-pleochroic; moderate index (1.63) but strong double refraction. Parallel extinction with dispersion  $\rho < \nu$ .  $H = 3\frac{1}{2}$ -4. Sp. gr. greater than 3.33. The plane of the optic axes is parallel to the plane of sym. 2H in olive oil is about  $43^\circ$ . Qualitative tests indicated a hydrated basic phosphate of Zn and Cu. The properties suggest somewhat the mineral *veszelyite*,  $7(\text{Cu, Zn}) \text{O}(\text{P, As})_2\text{O}_5 \cdot 9\text{H}_2\text{O}$ , differing however from the original *veszelyite* in crystal habit, color, and absence of As.

W. F. H.

RIEBECKITE-RHYOLITE FROM NORTHERN KARDOFAN, SUDAN. W. CAMPBELL SMITH. *Mineral. Mag.*, 19, 48-50, 1920.

While investigating the relics of early habitations near Jebel Katul a number of implements were found constructed of a fine grained blue-grey stone rich in riebeckite. The minute riebeckite flakes are arranged in roughly parallel lines producing a flow structure. Glass is entirely absent.

W. F. H.

A REPLACEMENT OF WOOD BY DOLOMITE. S. F. ADAMS. *J. Geology*, 28, 356-365, 1920.

More than 20 minerals are known to have replaced wood or plant remains. These include quartz, opal, calcite, aragonite, pyrite, marcasite, barite, cinnabar, fluorite, sulphur, malachite, azurite, gypsum, phosphorite, hematite, limonite, siderite, sphalerite, galena, chalcocopyrite, chalcocite, halloysite, talc and chlorite. To this list dolomite must be added. Dolomite was the earliest replacing mineral which crystallized along radial channels replacing the sapwood with the destruction of most of the cell outlines. Later silicic acid permeated the heartwood and caused its silicification.

W. F. H.

THE MINERALS OF THE MASSIF OF SLATA, TUNIS. H. BUTTENBACH. *Bull. soc. franc. min.* 43, 24-67, 1920.

Crystallographic descriptions of many specimens of galena, cerussite, calcite, phosgenite, and barite. Three new forms on calcite:  $\eta''$  (16.4.1),  $\Theta''$  (13.3.4),  $q$  (11.3.3), referred to the three rhombohedral axes.

E. F. H.

FIBROLITE (SILLIMANITE) AS A GEM-STONE FROM BURMA AND CEYLON. L. J. SPENCER. *Mineral. Mag.*, 10, 107-112, 1920.

The specimens from Burma came from the ruby mines at Mogok, and include a faceted gem and a number of water worn elongated pebbles. The cut stone is transparent, flawless and of a pale sapphire-blue color. Its wt. is 0.816 gram. Pleochroism is strong, varying from colorless to sapphire blue.  $H. 7\frac{1}{2}$  (the value 6-7 given in text books is too low, due to determinations made on aggregates and not on single crystals).  $n_{\text{Na}} 1.6584$ ,  $\beta 1.6596$ ,  $\gamma 1.6789$ ;  $\gamma - \alpha = 0.0205$ . 2E (air)  $52^\circ 2'$ ; 2V (calc.)  $28^\circ 2'$ . Other gem crystals from Ceylon (locality unknown), reveal another characteristic described as *fibrolite cat's eye*.

W. F. H.



A NEW MODEL ROTATING STAGE PETROLOGICAL MICROSCOPE. W. ALFRED RICHARDSON. *Mineral. Mag.*, **19**, 96-98, 1920.

An instrument designed to produce a smaller model with as many advantages of the larger types as possible. The microscope was constructed by James Swift & Son. When closed it is 12½ in. high. The body tube is 140 mm. long and 40 mm. in diam. so as to be suitable for microphotography. The rotating stage is 120 mm. diam. and is provided with mechanical motions. W. F. H.

THE FIBROUS GYPSUM OF NOTTINGHAMSHIRE. W. ALFRED RICHARDSON. *Mineral. Mag.*, **19**, 77-95, 1920.

All the gypsum veins occur in marls and are of the "cross fiber" type. A line of division (central parting) runs thru the veins parallel to the walls. These partings are marked by inclusions of marl which swell out into lenticles. Frequently the vertical fibers of gypsum are bent or broken at the central parting and show evidence of strain. It is thought that the veins were formed by a dehydration and contraction of the marls. The relief of pressure by rupture has caused spontaneous crystallization at numerous closely spaced centers. The crystals grew vertically as long as contraction continued. When contraction ceased, growth was resisted, and the stresses set up were transmitted to the central parting producing bending and other pressure effects noted. W. F. H.

A GRAPHIC METHOD FOR THE COMPARISON OF MINERALS WITH FOUR VARIABLE COMPONENTS FORMING TWO ISOMORPHOUS PAIRS. EDWARD S. SIMPSON. *Mineral. Mag.*, **19**, 99-106, 1920.

A graphic method employing two rectangular co-ordinates was found convenient in studying a mineral of the spinel group to bring out its relationship to the type minerals, spinel, hercynite, and chromite and to the intermediate minerals picotite, chrompicotite, magnesiochromite, and magnochromite. W. F. H.

ATOMIC ARRANGEMENT IN CRYSTALS. W. L. BRAGG. *Phil. Mag.*, **40**, 169-89, 1920. CRYSTAL STRUCTURE. W. L. BRAGG. *Nature*, **105**, 646-8, 1920.

The diameter of space occupied by atoms ("atomic domains") in crystals is approximately a constant for a given element. The radii of these "atomic domains" are given for a number of substances and their constituent elements. A curve is presented, showing the relationship between the atomic numbers of the elements and the radii of the domains. The alkalis have the greatest volumes, followed by the Ca group. Electro-negative elements possess the least diameters. The significance of these relations and the application of the Lewis-Langmuir theory of atomic structure are discussed. Photographs of models illustrating the structure of several crystals, the units of structure being spherical "atomic domains," are included. E. F. H.

THE CRYSTAL LATTICE OF THE HYDROGEN HALIDES. A. RIES. *Z. Physik*, **1**, 299-308, 1920.

The relation between ionization energy and molecular volume and that between the high ionization energies and low heats of sublimation in the H halides lead to the assumption that they have a molecular lattice. A strongly unsymmetrical structure for the halogen ions in the solid H halides is indicated. E. F. H.